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Cascade sensitivity studies for KM3NeT

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Summary. — KM3NeT is a future neutrino observatory to be built in the Mediterranean Sea. Its main astrophysical goal it to search for cosmic sources of neutrinos. The status of searches for diffuse fluxes of cosmic neutrinos in the cascade channel are reported in this contribution. A signal analogous to that observed by the IceCube collaboration will be observed with a 5σ significance within one year of operation of the detector.

1. – Introduction

The IceCube Collaboration has recently reported [1] the observation of a diffuse, all flavour excess of high-energy neutrinos, not compatible with atmospheric expectations. This observation has opened the path to high energy neutrino astronomy.

The KM3NeT detector [2] is a future research infrastructure to be built in the Mediterranean Sea. It will comprise several thousands of Digital Optical Modules (DOMs), pressure resistant glass spheres housing 31 3-inches photomultiplier tubes (PMTs). DOMs will be distributed along vertical strings anchored to the sea-bed, each holding 18 of them. 115 strings arranged together will constitute a detector building block. A first construction step, namely KM3NeT/ARCA, will comprise 2 detector building blocks with an instrumented volume of about $1\,\mathrm{km}^3$.

Detecting the Cherenkov light emitted by particles produced after neutrino interactions in the surroundings of the detector, good pointing accuracy and energy resolution is achieved for all flavour neutrinos [3, 4].

2. – Sensitivity studies in the cascade channel

An event selection procedure based on three consecutive cuts has been used to isolate signal from background in the shower channel. Complete Monte Carlo simulations have been exploited in this optimisation. In the first step of the selection procedure only contained events are kept. This rejects most of the atmospheric muon background [5] entering the detector from above.

A further rejection of atmospheric muons is obtained with an energy-related cut, based on the total Time over Threshold of hits. Only hits that are causally connected with th reconstructed vertex are selected. A large part of the low energy atmospheric muons and of the atmospheric muon neutrino background [6, 7], dominant at lower energies, is rejected with this selection.

The final step to isolate the signal uses a machine learning algorithm based on the Boosted Decision Tree (BDT) [8]. Quality parameters from the available shower and track reconstruction algorithms are used as input for the BDT training. The BDT is trained to discriminate signal from background using simulated data-sets of atmospheric muons and electron neutrino charged current events. The output of the BDT is used with the reconstructed shower energy in a two-dimensional Model Rejection Factor minimisation procedure [9] to find the optimal selection to separate the signal from the remaining atmospheric background. This minimisation produces a sample of 16.1 signal and 8.4 background events in one year of operation of the detector. This allows a 5σ discovery of the IceCube signal with 1.3 years of effective livetime of the detector.

A further improvement of this result is reached when applying at the last step a maximum likelihood fit in the two dimensional event rate plane of the reconstructed shower energy and the BDT output as in the track channel analysis [10]. This boosts the discovery potential by approximately 25% in time for a 5σ discovery, which would then be possible after roughly 1 year of operation with the ARCA detector.

3. – Conclusions

The future neutrino telescope KM3NeT will be greatly sensitive in searches for high energy neutrinos in all flavours analyses. A 5σ discovery of the IceCube signal flux can be achieved in about 1 year of operation using the cascade channel alone. The good angular and energy resolution of the telescope will allow detailed studies of the signal and of its sources.

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